Claims

1. A method of debonding two or more surfaces or supports or layers of an adhesive system, the adhesive system comprising an adhesive composition at its bonded surface(s), the composition being placed between said surfaces or supports or layers, and the adhesive composition comprising an adhesive agent and/or a primer and/or a cleaner at its interface and dispersed therein thermoexpandable microspheres, in order to debond the system a sufficient power level of thermal radiation and/or thermal energy is provided which concentrates on the adhesive surfaces so as to expand the microspheres in the adhesive and/or a primer and/or a cleaner layers and so causes weakening of adhesive surface forces at the interface of said layers in the adhesive system.

2. A method according to claim 1 further comprising the step of curing the adhesive composition prior to debonding it.

3. A method according to claim 2 wherein the curing step comprises providing a power level of thermal radiation and/ or thermal conduction and/or thermal energy which passes through the adhesive composition so the contents of the expanded microspheres leach or migrate through their porous shells into the matrix of the composition.

4. An adhesive system comprising curing an adhesive composition and/or de-bonding the same adhesive at its bonded surface, the composition being placed between two or more surfaces of supports or layers, and the adhesive composition comprising an adhesive and/or cleaner and/or primer at its interface and dispersed therein thermo-expandable microspheres the system comprising the steps of:

(i) activating a method of curing the composition by providing a first power level of thermal radiation and/ or thermal conduction and/or thermal energy which passes through the adhesive composition so the contents of the expanded

microspheres leach or migrate through their porous shells into the matrix of the composition and ;

(ii) de-bonding adhesive interfaces of the same surfaces of supports or layers by providing a second power level of thermal radiation and/ or thermal conduction and/or thermal energy which concentrates on the adhesive surfaces so as to expand the microspheres in the adhesive and/or cleaner and/or primer layers and so cause weakening of adhesive surface forces in the interface of the adhesive composition.

5. A system according to claim 4 wherein step (i) is performed after adhesive composition deposition and step (ii) is performed days, weeks, months or years apart.

6. A method or system according to any preceding claim wherein the microspheres comprise a co-polymeric shell which encapsulates an expanding agent for the debonding microspheres and a curing agent or catalyst mixed with an expanding agent for step the curing microspheres.

7. A method or system according to claim 6 wherein the expanding agent is selected from the group comprising an expandable gas, a volatile agent, a sublimation agent, water, an agent which attracts water or an explosive agent.

8. A method or system according to any of claims 2 to 7 wherein the microspheres encapsulating the curing agent have a larger cross sectional diameter than those encapsulating the expanding agent.

9. A method or system according to any of claims 2 to 8 further comprising a curing activator.

10. A method or system according to claim 9 wherein the curing activator is activated by an applied thermal energy or by its own energy.

11. A method or system according to any preceding claim wherein the adhesive is polyurethane or polyvinylchloride or an MS polymer or an epoxy resin.

12. A method or system according to any preceding claim wherein the microspheres are activated in a temperature range of about 45 to 220 °C for the debonding phase.

13. A method or system according to any of claims 2 to 12 claim wherein the proportion of microspheres encapsulating the curing agent are activated at a different temperature from those used in the debonding phase the temperature difference being between 20 to 100 °C.

14. A method or system according to any preceding claim wherein the microspheres used in debonding microspheres encapsulating the expanding agent comprise about 3-5% weight in the cleaner and 5-10% weight in the primer at the adhesive interface.

15. A method or system according to any one of claims 2 to 14 wherein the microspheres used in curing encapsulating the curing agent or catalyst comprise about 2-3% weight of the composition.

16. A method or system according to any preceding claim wherein the thermal radiation and/ or thermal conduction provided to the microspheres is provided by a means comprising a source of IR or UV electromagnetic radiation, or from a convection oven or from electrical means, a battery or a laser or from an ultrasonic source or from gas or from white light or microwaves or sonic waves.

17. A method or system according to claim 16 wherein in the instance of using IR radiation it is provided as a wavelength of about 800-1400 nm to 2000-6000 nm and concentrates heating radiation on the microspheres in order to reach their activation expanding temperature in advance of their degradation temperature.

18. A method or system according to any preceding claim wherein the thermoexpandable microspheres are provided embedded in or coated on to a tape or mesh or film or attached to a wire or filament or fibre.

19. A method or system according to any preceding claim wherein the microspheres are coated in a black material.

20. A method or system according to any of claims 1 to 17 wherein the microspheres are coated with or encapsulate a monomer and/or with nanoparticles dispersed in the porous initial microsphere shell.

21. A method or system according to any preceding claim wherein the microspheres act as a vehicle or transporter or barrier or dispersing aid or aid to prevention of clustering of particles or nanoparticles in a mixture comprising a binder and solvent, the microspheres either encapsulating a desired agent or being coated with it.

22. A method or system according to any preceding claim wherein the microspheres are dispersed in an arrangement of micro-wires so as to form a polygonal arrangement.

23. A method or system according to claim 22 wherein the micro-wires are about 100-200μ in length.

24. A method or system according to claim 23 wherein the micro-wires are about 2-20μ in diameter.

25. A method or system according to any one of claims 22 to 24 wherein the composition comprises about 1-10% volume of micro-wires.

26. A method or system according to any preceding claim wherein the thermoexpandable microspheres are attached to a contact surface of one or more of the components which it is desired to attach and/or separate or on an internal surface of the components or at an interface of the cleaner and/or primer of said components.

27. A method or system according to any preceding claim wherein the adhesive composition comprising the microspheres is provided in a continuous or discontinuous predefined or in spots in path or channel or groove or line or concentric circles provided substantially around the periphery of one or both of the contact surfaces of the items which it is desired to attach or detach.

28. A method or system according to any preceding claim wherein the depth and breadth or thickness and wideness of the adhesive composition may be uniform or may vary as required in areas of the surface(s) which need to be attached or detached.

29. A method of attaching or bonding two or more surfaces together comprising:

(i) applying an adhesive composition according to any preceding claim to one or more of the contact surfaces of each or all items which is to be bonded together; and

(ii) supplying sufficient thermal radiation and/ or thermal conduction to the composition via contact with one or more of the contact surfaces of each or all items which is to be bonded together so as to cause a proportion of the thermoexpandable microspheres to expand and optionally to further release a curing agent into the composition during the bonding process.

30. A method of detaching or debonding two or more surfaces that have been bonded together comprising, supplying sufficient thermal radiation and/ or thermal conduction to a surface having coated thereon or attached thereto the composition as defined in either claim 1 or claim 4, the thermal energy being supplied to one or more of the contact surfaces of each item which are to be detached/separated so as to cause

the thermoexpandable microspheres to increase in volume and to become a pressure activator so as to debond the interfaces of the adhesion system.

31. A method according to claim 30 further including any one or more of the features recited in claims 2 to 29 regarding the debonding of interfaces.

32. An apparatus for attaching or detaching two or more surfaces that have been bonded together comprising an IR emitting device comprising at least one bulb, at least one lens and at least one reflecting mirror mutually arranged so that heat is directed or focused only at an adhesive interface or a path where the thermoexpandable microspheres are purposely present.

33. An apparatus according to claim 32 capable of emitting IR radiation in the range of about 800-1400 nm to 2000-6000 nm.

34. An apparatus according to either claim 31 or 32 that is automated and operably linked to a computer programme providing information to device sensors of an adhesive bonding path.

35. An apparatus according to any one of claims 32 to 34 mounted on a mobile unit so that it is free to follow a predefined adhesive bonding path.

36. An apparatus according to any one of claims 32 to 35 capable of concentrating an IR beam at certain partial points of the surface which it is desired to bond or de-bond in different steps at command.

37. An apparatus according to any one of claims 32 to 36 that is pre-programmed to follow a specific bonding path in direction, width and breadth.

38. A method of de-bonding an adhesive composition, the composition being present at an interface and being placed between two or more surfaces of vehicle

glazing or vehicle panel(s) or part(s) the composition comprising an adhesive or cleaner and/or primer and thermoexpandable microspheres dispersed therein the microspheres having a diameter of between 10-50 μm and an activation temperature range of between 110-210 C° and encapsulating at least one blowing agent the debonding being effected by exposing the microspheres power level of thermal radiation and/or thermal energy that results in a temperature received by the microspheres in the range of 110-210 C°.

39. A method according to claim 38 further comprising curing the adhesive composition prior to bebonding the curing comprising providing microspheres of 30-50 μm in diameter with an activation temperature range of between 50-100 C° the microspheres encapsulating a curing agent and/or catalyst and/or activator and effecting curing by exposing the microspheres power level of thermal radiation and/or thermal energy that results in a temperature received by the microspheres in the range of 50-100 C°.

40. A method of curing an adhesive and de-bonding the same adhesive from automotive glazing or panels or parts comprising applying a composition comprising an adhesive and thermoexpandable microspheres dispersed therein, a first set of microspheres having a diameter of between 30-50 μm and an activation temperature range of between 50-100 C° and a second set of microspheres having a diameter of between 10-50 μm and an activation temperature range of between 110-210 C° the second set of microspheres being present at an interface of the adhesive or cleaner and/or primer, the composition being placed between two or more surfaces of the glazing or panel or part(s) and:

(i) activating curing of the composition by exposing it to a first power level of thermal radiation and/or thermal energy that results in a temperature received by the microspheres in the range of 50-100 C°; and

(ii) de-bonding the adhesive system at its interfaces by exposing it to a first power level of thermal radiation and/or thermal energy that results in a temperature received by the microspheres in the range of 110-210 C°.

41. A method according to any one of claims 38 to 40 further comprising any one or more of the features recited in claims 2 to 28.

42. A method according to any one of claims 38 to 41 for the removal of vehicle glazing or panels or parts in an end of vehicle life process.